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LANSCE Short-Pulse Spallation Target Change

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Abstract-- *The Los Alamos Neutron Science Center (LANSCE) short-pulse spallation source provides neutrons for research at the Lujan Center. We recently upgraded the target system to implement a modular design to reduce the target change-out time from several months to about three weeks and permit the proton beam current to be raised to 200 μA. The project included a new target-moderator-reflector system mounted on a single insert, a new suite of moderators for four new flight paths, improved support systems, remote handling capability, and a new bridge crane. In 2002, we performed a target change operation. The new design required 37 days of effort to complete the change and reduced the radiation exposure from previous operations by a factor of twelve. We will review our experience with this target change operation.*

I. INTRODUCTION

The Los Alamos Neutron Science Center (LANSCE) short-pulse spallation source provides neutrons for research at the Lujan Center. Between January 2 and July 2, 2002, the target system (consisting of a single module with targets, moderators, and reflectors) was replaced. The operation took 27 people 37 days of effort with a cumulative radiation dose of 9.4 mSv. In contrast, a 1991 target change operation required a rotating crew of approximately 60 people five months with a 120 mSv cumulative dose of 120 mSv.[1] We will review our recent experience performing the target change operation and use the 1991 target change operation for comparison. The reduction in time, personnel, and radiation exposure was accomplished by performing and implementing a comprehensive facility design review with focus, in part, on reducing the time to change target system components while maintaining the target system neutronic performance.[2] This latest target change will be reviewed with emphasis on a few of the more significant lessons learned in the areas of facility and target system design as well as ALARA practices.

II. FACILITY SYSTEM DESIGN

There is no substitute for a well conceived, rigorously reviewed facility operational concept. Successful implementation of a comprehensive review of the target replacement concept was required to realize the improvements described above.

The 1991 target was a hand stacked arrangement of moderators, reflectors, steel shielding, and, of course, tungsten targets. The components had to be hand stacked because the facility had no ability to handle larger, heavier assemblies. The target resided inside a shielded enclosure, called the Target Cell (similar to a standard hot cell), which could only be accessed from the side through a 2m by 2m shield door. Component weight was limited by the capacity of a 5 ton bridge crane installed inside the Target Cell and by the capacity of a 20 ton rail cart which could be rolled through the shield door to carry out components being removed and their associated shield casks.

To overcome the existing facility equipment handling limitations, the target handling concept was revisited so that larger, heavier components could be safely and remotely handled. The concept which was adopted is depicted in Figure 1. The target facility was upgraded by installing an exterior bridge crane with both a 10 ton and a 30 ton hoist. A hole was cut in the Target Cell roof, centered over the target, so that each hoist could have access to target system components. A thick steel plate was installed in the new roof hole to support shield blocks when access was not required and to support a shielded cask during target change operations. With these improved facility handling capabilities, larger target assemblies could be remotely lifted into shielded casks and removed from the Target Cell in a single lift.

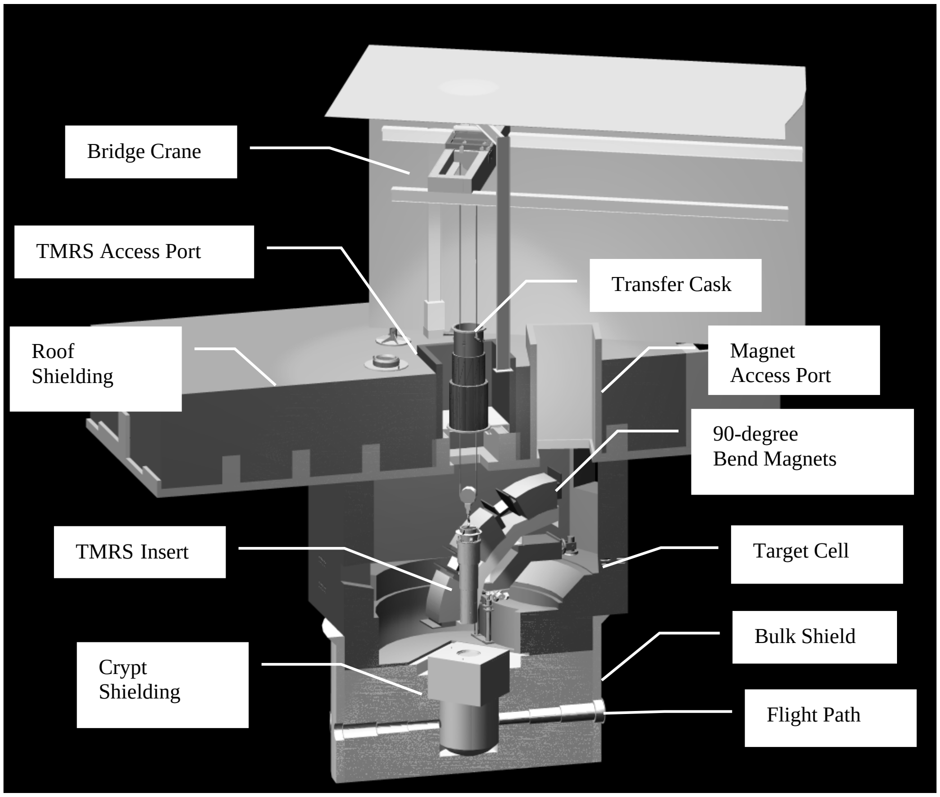

Figure 1. Cutaway view of the Target Cell during a target change.

III. TARGET SYSTEM DESIGN

III.A. Modular Design

To optimize the benefits from the facility upgrades, a modular target design was adopted so that multiple handling operations were not required to replace key components. Also, radiation shielding was redesigned so that it did not interfere with removal of the new modular assembly. All targets and moderators were consolidated into a single module. Similarly, all reflectors and steel shielding which surrounded the targets and moderators were either incorporated into that module (referred to as the Target Moderator Reflector System or TMRS) so that they would not have to be handled separately, or re-designed so they would not interfere with handling operations.

The improvements realized with the facility upgrades and target re-design (completed in 1998) proved valuable during the 2002 target change operation. In 1991, it took five weeks to remove five layers of steel shielding and two magnets to gain access to target system components (~10,000 kg of steel), four weeks to replace the target and moderators, and another five weeks to re-install the steel shielding and magnets.[1] During the 2002 target change, removal of the TMRS took two days and installation of its replacement required one day.

III.B. Component Materials

Material selection can have a significant impact on the ability to work on target systems—the most recent target change operation was no exception. Earlier versions of the Lujan Center target used an unclad machinable tungsten alloy (~95% W) as the target material. However, operating experience demonstrated (and visual inspection confirmed) that this material did not exhibit good corrosion resistance under normal operating conditions. Figure 2 shows this version of an upper tungsten target inside its enclosure following operation. It is clearly cracked, corroded, and eroded from beam operations and target coolant flow. Subsequent calculations and measurements determined an approximate 8% reduction in weight of the tungsten target material (J. Donahue).

Figure 2 Upper Tungsten Target Assembly

Some of the tungsten (and spallation product) material was deposited in target coolant piping resulting in elevated general radiation levels during the 1991 target change operation. General area radiation levels were 3.5 mSv/hr with significant “hot spots” ranging from 180 to 380 mSv/hr three months after cessation of beam delivery to the target. These radiological conditions necessitated target cooling system filters be changed, portable shielding be installed, and HEPA filtered respirators be worn whenever working in the Target Cell—all of which added to the time and personnel exposure required to complete the job.

The tungsten alloy was replaced with pure tungsten target material (again unclad) during the target re-design effort for better target corrosion resistance. Operational experience validated the decision. The result for the 2002 target change operation was, with ~58% more beam on target than on the target changed in 1991, the general radiation levels were 0.1 to 0.3 mSv/hr and the highest “hot spot” was 2.5 mSv/hr on the proton beam line (unrelated to the tungsten target) 2.5 months after beam delivery ended. No temporary shielding was required nor were HEPA filtered respirators required for entering the Target Cell.

IV. ALARA PRACTICES

Several practices were used to minimize radiation exposure and to control the risks of moving a highly activated assembly (~190 Sv/hr on contact). Some of these were:

- Extensive pre-job planning
- Detailed written procedures and checklists
- Use of experienced personnel for critical tasks
- Daily pre-job briefs
- Use of remote handling equipment, remotely controlled CCTV cameras, and remotely controlled cranes
- Daily inspection of critical equipment
- Use of mock-ups and dry runs

The first four are standard practices and will not be discussed here. Similarly, the remote handling equipment employed at LANSCE is covered in detail in other sources.[3] The last two line items, daily inspections and dry runs, will be discussed along with our particular lessons learned.

IV.A. Daily Inspections

Daily inspections were performed on critical equipment. “Critical equipment” included all cranes, forklifts, and remote handling components (manipulators, cameras, etc.) that would be used to handle the TMRS (old or new). Due to the age and location of some of the equipment (such as bridge cranes), we found the inspections to be vital to the successful 2002 target change operation and that “daily” was not too frequent an inspection interval.

The bridge cranes used in the operation, particularly the two located outside and exposed to the elements, presented a series of challenges. Although the cranes performed well during the target change operation, we had a series of crane failures (during the daily checks) including:

- Loss of power because exterior bus bars had bowed from thermal expansion and contraction resulting in the loss of electrical contact,
- Loss of remote and local control because bird nests and/or insects shorted crane mounted control electronics,
- Loss of remote and local control because moisture shorted crane mounted control electronics,
- Failure of crane interlocks because wind-blown sand jammed crane mounted interlock switches,
- Loss of crane motion because drive wheels lost contact with the bridge rail,
- Loss of crane motion because crane wheels would not articulate and follow the bridge rails.

The value of checking the cranes daily can not be over-estimated and was key to identifying and correcting problems early before they impacted operations.

IV.B. Dry Runs

It is difficult to envision all possibilities of a complex operation before it takes place and this was our experience in performing this first TMRS target change. Dry runs were instrumental in identifying short comings in our assumptions and procedures before they became problems. Two examples follow.

IV.B.1. 30 Ton Hoist Cable Will Stretch

As part of our dry runs, we took the shield cask which would be used to hold the activated TMRS, loaded it with a dummy target assembly (a steel plug the same size and about the same weight as the TMRS), and transported the loaded cask over the entire route that would be used for the actual target change operation. In doing so, we discovered that the loaded cask would not fit into the identified storage building even though earlier measurements showed adequate clearance for the installed crane to lift the cask into the building and even though the empty cask had been moved into and out of the building over the same route. We discovered that the added weight of the dummy TMRS caused the 30 ton hoist cable to stretch just enough (~2.5 cm) that the load would no longer clear a concrete shield wall. We had not anticipated the hoist cable stretching under load, but we were able to resolve the issue by changing the rigging scheme to provide additional clearance.

IV.B.2. 10 Ton Hoist Cannot Reach Load

Another issue identified during dry runs involved installation of the new target assembly. It was envisioned that the new target would be installed using the 10 ton hoist on the exterior bridge crane. However, during dry runs, it was discovered that a nearby control building interfered and that the 10 ton hoist could not be centered over the load. The 30 ton hoist could not be used instead because the cable spread off the hoist cable drum became too large for the hook to fully lower the new TMRS into the Target Cell without the crane cables rubbing on the steel roof plate. Because the problem was identified early, we were able to design and build a support stand for the Target Cell roof that would allow the TMRS to be initially picked up by the 30 ton hoist, transported to the Target Cell roof, and then transferred to the 10 ton hoist for lowering into place inside the Target Cell.

V. SUMMARY

The LANSCE short-pulse spallation source target was successfully changed out in 2002. The operation realized significant savings in manpower, time, and exposure over previous target change operations (such as in 1991). The reduction in time, personnel, and radiation exposure was accomplished by improving the facility system design, by improving the target system design, and by employing several ALARA practices.

TABLE I. Target Change Comparison

	1991 Target Change[1]	2002 Target Change
Time (days)	~ 111	37
People	~ 60	27
Target Integrated Current (mA-hr)	245	386
Target Rad. Level (Gy)	60 (measured)	190 (calculated)
Cumulative Dose (mSv)	120	9.4

VI. ACKNOWLEDGMENTS

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